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ABSTRACT

This report describes the relationship between maternal malnutrition and child development. The report is divided into three sections. The first section, which describes child development, focuses on brain, mental, and psychomotor development. The second section describes the methodological difficulties of measuring effects of malnutrition on the brain, and focuses on the value and limits of animal experiments which investigate anatomical and behavioral modifications, and reversibility disorders caused by malnutrition. This section also describes difficulties encountered in field work. Areas of difficulty are those concerning psychometric tests and the measurement of intelligence and social competence, and the definition of test variables. An additional area of difficulty concerns investigations which include retrospective and prospective surveys and intervention-type investigations. The third section discusses the interaction between malnutrition, development, and environment. This section focuses on studies based on observation of interactions between: (1) malnutrition and development; (2) environment and malnutrition; and (3) mother and child. Research on relationships between poverty, growth, and development in Cali, Colombia, is also discussed. The report concludes with a glossary of the main psychometric tests and a list of books for further reading. (RJC)

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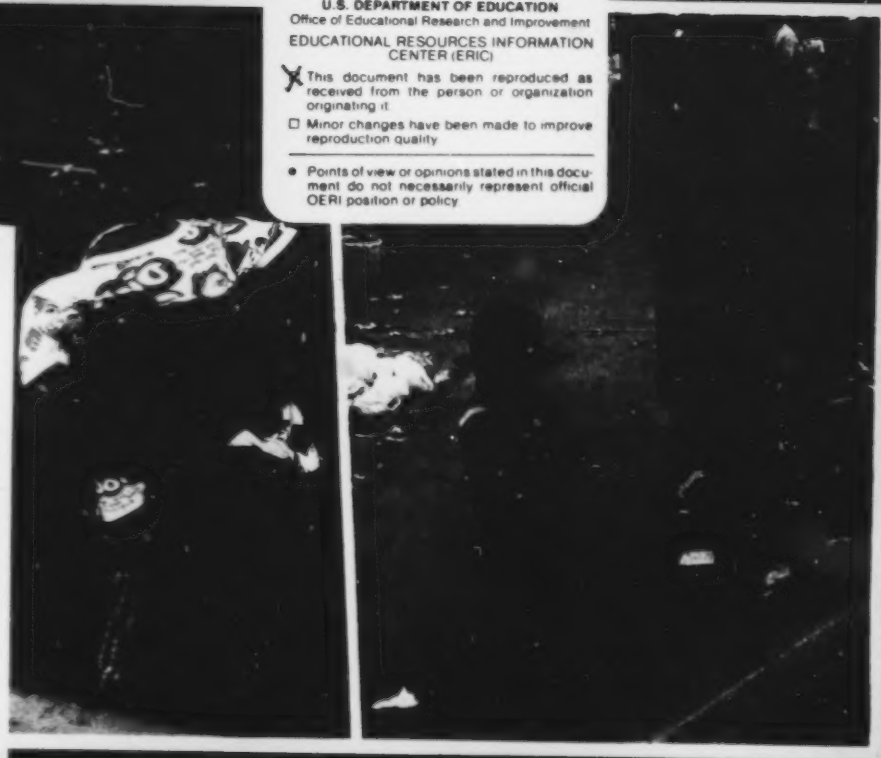

1988 - N° 177 - DIET, ENVIRONMENT AND CHILDREN'S DEVELOPMENT

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ICC soon turned essentially toward Third World children and devoted its activities to the training and education of personnel with social, educational and administrative responsibilities as well as medical and paramedical workers. The desire for greater efficiency has led it to work increasingly with trainers and to concentrate its efforts on the methodological and educational aspects of mother and child care programmes.

ICC is also engaged in an attempt to further study — and — action on some aspects of the life and health of children and their family, so as to contribute to practical improvement, particularly in the fields of growth, nutrition, planned parenthood, the control of transmissible and nutritional diseases, preschool and school education, the needs of disabled and underprivileged children, etc.

Over this period of more than 30 years, a large amount of documents on children and adolescents, mostly from the developing countries, has been accumulated. This international documentation has been classified and sorted out, and has been computerized since 1983 : a bibliographic data base (BIRD : "Base d'Informations Robert Debré") may be consulted anywhere in the world, through international communications networks. ICC also publishes periodicals, educational documents and specialized bibliographic bulletins.

As for its legal status, the International Children's Centre is a foundation under french law of recognized public utility, administered by an executive board with broad international membership.

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EDITORIAL (1)

Chronic malnutrition is the most prevalent kind of malnutrition among children, and among mothers as well. For many years now, the International Children's Centre has given considerable attention to investigations concerned with the influence of malnutrition, and more specially of chronic malnutrition, on the psychological-emotional, cognitive, motor and physical development of small children.

The findings resulting from such studies are most important for the planning and implementation of programmes whose objective is a more harmonious development for children. Most schemes aimed at the rehabilitation of undernourished small children generally do no more than provide larger amounts of higher quality food, for a duration of 2 to 4 or 5 weeks ; that is, until the children have at least partially recuperated from their weight deficit. This action is often combined with nutrition education for mothers.

It is a fact, however, that malnutrition, the visible result of a dietary intake that does not fulfill the nutritional requirements of a group of individuals, is rarely an isolated phenomenon. With the exception of some rare cases of anatomical malformations or physiological dysfunctioning, it is almost always associated with social and health factors which are partly responsible for restricting children's development. These include poor hygiene, infectious diseases, socioeconomic difficulties and the educational level of those around them, which affects the intensity and quality of stimulation. The respective influence of each of these factors is unclear.

Research has now considerably advanced our understanding of the effects of nutrition on the organic structure of the brain, and consequently on its physiological functions. Further work is under way, however, in order to determine whether behaviour is affected by these structural modifications. Conclusions on this point remain quite vague, since behaviour is not a simple function of the brain, but a "complex whole", insufficiently defined for the moment, and influenced by many intertwined social factors.

One major difficulty subsists in all present-day studies : that of selecting tests appropriate to each particular culture, for the evaluation of the state of children's psychomotor and intellectual development.

Studies of animals have contributed to a better understanding of the influence of malnutrition on the brain structure, and to the extrapolation of findings to the human brain. The use of behavioural studies is more delicate, but may be valuable in refining methodological approaches.

In view of the doubts subsisting as to the exact effects of selective undernourishment and malnutrition during children's gestation and first years of life on their learning, behavioural development, adjustment to changes in their surroundings, emotional control

(1) For a more complete picture of children's overall development, the reader is referred to issues 164 and 170-71 of this journal.

and personality development, the International Children's Centre decided to bring together investigators working on this question, in order to redefine guidelines for its future activities in this field.

The conclusions of the research presented by renowned specialists on this subject, as well as of a seminar held at the International Children's Centre in 1986, have been published in a book entitled "Early Nutrition and Later Achievement" (published by Academic Press).

The broad overview presented in this issue, following a short summary of the present state of our knowledge and of the methodological difficulties encountered, is an attempt to popularize the most important conclusions drawn from this research ; those which are most useful in guiding activities whose objective is to combat malnutrition and contribute to children's harmonious development. Readers are invited to reflect on the following general topics :

— chronic malnutrition is not simply caused by insufficient dietary intake, but is an integral part of a more generally poverty-stricken environment, and efficient, lasting results will be achieved by acting simultaneously on all of the causes ;

— all efforts aimed at preventing malnutrition must take both the dietary and educational role of mothers into consideration ; the utmost attention should be given to mothers' nutritional status, their preparation for the child's arrival and, of course, how children are fed, but also the psychological-emotional stimulation they receive after birth ;

— the need for programmes aimed at stimulating children to be made an integral part of the surveillance of nutritional status ;

— dietary and educational action within programmes for the nutritional rehabilitation of children should be planned simultaneously and cover a sufficiently long period of time.

CHILD DEVELOPMENT

The term development, as applied to children, designates the overall, ongoing, dynamic process by which the human child is gradually transformed, from conception to adulthood. The child is a constantly changing being.

Children's overall development is the combined result of physical development ; that is, of processes involving somatic growth and the maturation of cell structures and of their functions, and of mental development, which more specially affects the sensory, motor, cognitive, social and emotional spheres.

While children's development is genetically determined, it is conditioned to a large extent by the physical, family and sociocultural environment, and the proportionate roles played by heredity and environment are not known. A series of chronologically predetermined stages occur, involving new achievements and a gradually increasing ability to adjust to a variety of situations, with each stage serving as a stepping-stone for the following one.

Investigators in different disciplines have identified the many spheres of development and plotted their normal course. Children's progress may then be traced, and the variations in their achievements around a given age may be established, so as to detect any lags or dysharmonies.

Physical growth is the most easily observable and quantifiable aspect of children's development. Anthropometric indicators such as height, weight and different circumferences are relatively well known and are used to locate each child with respect to mean values which should in no case be confused with normalcy.

Mental development involves the establishment of the many mechanisms and networks of which social and intellectual life is composed. Although the definition of landmarks for psychomotor, sensory and emotional development is more delicate, owing to considerable individual differences and to the social and cultural influence of the surrounding environment, the observation of large numbers of children has provided valuable indications.

No single examination, however complete, will furnish sufficient information for the monitoring of all aspects of development. This requires successive checks, through which children's evolution may be followed, and which cover all of the spheres, to make sure that they are progressing harmoniously.

The development of the brain is another question. The different functions have been located anatomically, through the observation of disorders caused by certain lesions, as well as by experiments on animals and the elucidation of human pathology. However, the process by which the brain grows and develops is still insufficiently understood, owing to the great complexity of the structures involved, the close intertwining of different aspects of development and the influence of the environment, not to mention the difficulties in investigating these questions.

BRAIN DEVELOPMENT

Growth of the brain does not parallel that of the rest of the body. Measurement of the head circumference provides a rough estimation of the volume of the brain. It averages ± 35 cm at birth, and reaches ± 47 cm at age one year. Most of the brain's growth occurs during the last three months of gestation and the first year of life. The brain attains 90 % of its adult volume by age six years, whereas the rest of the body then only represents 40 % of its adult volume. Brain tissue development, which is in advance of the rest of the body, reaches a peak toward the age of three years (cf table 1).

Table 1

Progression of weight, height, head circumference and weight of brain from birth to age 6 years

	WEIGHT (kg)	HEIGHT (cm)	HEAD CIRCUMFERENCE (cm)	WEIGHT OF BRAIN(g)
GESTATION				
3rd month	0.0450			
5th month	0.500			
6th month	1	35		
8th month	1.500			
BIRTH	3.250	50	35	325
5-6 months	6.5 (BW × 2)			600
12 months	10 (BW × 3)	70-72	47	900
24 months	13 (BW × 4)	82-84-	49.5	1 000
48 months	16	100 (BH × 2)		1 300
6 years	20	113	54.5	

BW = Birth Weight BH = Birth Height

Source : How to feed young children. In : Children in the Tropics. Paris. International Children's Centre. 1982 ; N° 138-139-140.

The brain as a whole does not grow regularly, however : there are two periods of rapid brain growth.

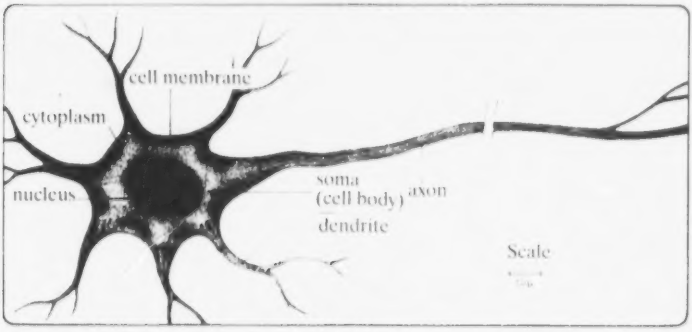
The first begins during the first three months of pregnancy, more specifically on the sixth week of amenorrhoea, during the period of embryogenesis (1), when the neurones and glial cells are formed ; these will remain practically stable in number throughout the individual's life. The lifetime brain potential acquired then is approximately 10 billion cells.

(1) Embryogenesis : a series of transformations by which the fertilized ovum develops into an embryo. It begins after fertilization and ends toward the eighth week of gestation. It is characterized by intense cell division.

Malformations of the neural tube may occur at this point. The role of the mother's nutrition in the development of the foetal brain during this first trimester has been evidenced by two studies. These have shown that when at-risk women who had given birth to one child with a neural tube defect were given vitamins, and perhaps more specifically folic acid, during the period immediately following conception, the frequency of recurrence of this type of embryopathy in their second or third child would be reduced. There is clearly no indication that neural tube defects are caused by a temporary folate deficiency, and their pathogenesis is probably far more complex, but the results obtained with folic acid do provide strong encouragement for use of this measure, in the present context, for the prevention of neural tube defects (spina bifida, etc) in the offspring of at-risk women.

The second phase of rapid brain growth lasts from the thirtieth week of gestation until the age of 30-32 months. During this period a great many brain structures and biochemical routes are developed, and a whole system of interconnections is established, with the growth of the dendrites and the formation of synapses (cf figure 1). The mean volume of the brain cells increases and their ramifications are multiplied, numbering as many as 100,000 per neurone. Myelinization (1) of the nerve fibres involved in motoricity — without which they would be unable to function — occurs at the same period.

Figure 1 - Nerve cell



Dendrites : the multiple processes branching out from the nerve cell ; they are in contact with the terminal axons through the synapses, and collect impulses before transmitting them to the soma (nerve cell body).

The dendrites converge toward the cell body. A single axon leaves the cell body : it is the outgoing cable of the nerve cell. At the other end, its tree-like endings contribute to the formation of synapses.

A synapse is the junction between nerve cells or between nerve cells and other categories of cells (muscle cells, ganglion cells). Some synapses are electric, others are chemical and make use of neurotransmittors (chemical substances active in the transmission of nervous impulses).

(1) Myelin is a complex lipoproteic substance forming a sheath around certain nerve fibres (the white substance in the spinal cord and the brain).

This period of growth is particularly vulnerable and sensitive to external factors such as aggressions and dietary restrictions. Some parts of the brain, such as the cerebellum, grow more rapidly than others.

Brain development is a process through which events occur in a complex, interrelated fashion, in a definite order, at specific, predetermined times. There is no way of repairing harm done by an aggression. J. Dobbing has clearly shown that there is no equivalent in children of the adult brain's resistance to malnutrition. The rapidly developing brain is extremely vulnerable, in direct proportion to its rate of growth.

In developing countries, the health of small children is heavily dependent upon their mother's nutritional status, which is often threatened during pregnancy and lactation. This conditions children's growth, and the growth of their brain in particular. However, when the expectant mother's diet is insufficient, a considerable amount of foetal tissue is built up nevertheless. Significant modifications occur in the mother's metabolism, which spare the foetus as much as possible. The pregnant woman stores fats for use by the foetus during the rapid growth phase, then for her own energy requirements for milk production.

The protein "cost" of gestation is harmoniously spread over its entire duration. An intra-uterine nutritional deficiency will first affect the foetus' overall weight, then the thymus, liver and height, and do relatively little damage to the brain.

Despite these facts, when the mother's nutritional status before and during pregnancy is unsatisfactory, growth of all of the foetal organs is impaired, despite their relative protection.

If malnutrition is lasting or severe, and above all if it occurs during a phase of rapid growth of the brain tissue, it will definitely affect the postnatal development of the child's brain structures. In any case, the influence of the mother's nutritional status during pregnancy is undeniable. Last, the quality of nutritional rehabilitation conditions the reversibility of functional disorders caused by the bio-anatomical modifications of the brain subsequent to undernutrition (cf chapter on animal experiments).

MENTAL AND PSYCHOMOTOR DEVELOPMENT

The growth and maturation of the child's nervous system result in a number of sensory, motor, cognitive, psychological and emotional achievements, most of which occur during early childhood.

These different aspects of development are closely interwoven, and depend on the influence of the child's environment as well as on genetic and anatomical factors.

To mention only a few of the factors affecting child development, we may list :

— diet ;
— living conditions : housing, sanitation, extent of exposure to disease ;
— access to and quality of medical care ;
— family size, interbirth interval ;
— rhythm of everyday life, balance between activities, rest and sleep ;
— parents' health status, educational level and socioeconomic status ;
— quality of the mother-child relationship and emotional atmosphere within the family : affection shown to the child, his or her place in the family, feeling of security, etc.

These factors are all difficult to individualize, since they interact closely. For instance, diet affects growth through the quality and quantity of food ingested, but the emotional exchanges, language learning and specific motions and behaviour that accompany the act of eating in each culture may also make it a special time for mother-infant contact.

Sensory and motor development

It is here that landmarks are easiest to find. Maturation of the nervous system goes hand in hand with the development of motor and sensory functions. The progressive myelinization of motor fibres provides muscle tone, after which walking, coordination between sight and grasping — so that the child may take an object, for example — sphincter control, etc, may occur. Hearing, smell and sight develop, followed by the gradual acquisition of language.

Outside stimulation is required, however, for the achievement of these different accomplishments. Children deprived of maternal care, in orphanages, for instance, definitely suffer from psychomotor retardation, owing to a lack of communication. Development can only progress harmoniously if the child receives support from exchanges with others.

Motor development is less conditioned by the environment. An emotionally deprived child will eventually learn to walk, but will retain behavioural problems (enuresia, character and speech disorders), with a risk of future social maladjustment.

Cognitive development

This includes the learning of knowledge of all sorts, which results in the development of intelligence. This complex notion is based on the ability to adjust to new situations. It includes the power to comprehend, the ability to understand the relations between ideas and situations, to solve problems, the faculty of abstraction and the ability to formulate and integrate concepts.

A concept is a general, abstract mental representation of an object or an idea, which applies to the total sum of knowledge possessed by any individual pertaining to a series of objects and beings ; it is a systematic response to a class of stimuli. The formulation and integration of concepts is the basis of thought, and represents the process by which some distance may be attained with respect to concrete actuality.

Some writers define intelligence as a type of behaviour differentiating human beings from other animal species, through their ability to reason, to think abstractly and to adjust to new situations.

According to Piaget, the development of intelligence is not a continuous, linear process, but is organized in three successive periods : sensori-motor intelligence, concrete operations and formal operations.

Sensori-motor intelligence

It takes shape during the first 18 months. In the course of this period, children learn to distinguish the world around them, to separate their "self" from the environment. Instinctive reflexes are replaced by patterned action. This involves series of motions resulting in reproducible acts (such as taking an object to suck on it, throw it, etc).

At the same time, children structure the real world around them : they construct the permanence of objects (a toy hidden under a piece of cloth continues to exist), explore the notion of causality, acquire a perception of spatial relations by moving.

Gradually, children become able to consider their body as an object among other objects, in their action.

The stage of concrete operations

It begins at the age of 18 months and continues until 11-12 years. Once sensori-motor patterns of action have been attained, toward the age of two years, children learn to speak. Their thought processes then gradually become operational.

The period ranging from age 2-3 to 7-8 years represents one phase in the organization of concrete operations, so named because thought remains bound to concrete experience and to the notion of reversibility. For example, the notion of "putting together" is only conceived as an operation if it is viewed concommitantly with the notion of "separating" (putting together and separating two balls of clay, two sets of beads, etc).

The earliest operations pertain to objects that are present or easily represented, and not on spoken statements expressing hypotheses.

Symbolic thought is introduced by the acquisition of language, drawing and mental images, but thought remains connected with concrete perceptual elements. Gradually, the notions of conservation of quantity, volume and weight are integrated, concrete arithmetic problems may be solved and the notions of time and space are developed, but always with reference to some reality.

The stage of formal operations

At the age of 10-12, the thought process begins to "take off", to free itself from material reality. It may be applied to things other than objects that are present or concretely represented.

Adolescents develop an ability to reason correctly on the basis of hypotheses ; that is, of propositions whose truth or falsehood has not yet been determined. They may then examine the consequences that necessarily ensue from these hypotheses ; this is the beginning of the hypothetico-deductive thought process, on which the adult mode of thinking is based.

Children's cognitive development thus proceeds through a series of broad constructions, each of which extends the previous one and restructures it on another plane, only to go even further, constantly expanding itself. The order in which it progresses is constant, but the average ages characterizing the different stages vary from one individual to another, and from one social setting to another.

The development of intelligence is linked with :

— body growth and the maturation of the complex whole formed by the nervous system and the endocrine systems. Knowledge of the maturational preconditions required for the elaboration of the general operational structures is still very incomplete, however ;

— exercise and experience, derived from the child's manipulation of objects ;

— social and affective interactions and communication.

Here too, these three factors are completely intertwined. The result of their conjunction is the development of increasingly complex functional structures of the mind.

Social and emotional development

Early in life, children discover their body through its functioning. Their pleasure is of a sensori-motor type, and is self-sufficient. Their play is initially solitary, and leads them to differentiate themselves from the outside world.

Gradually, they discover a need for others, not simply to satisfy some material needs, but in order to communicate. Responses encourage them to perfect the messages they send out to others.

During the first year, children mostly establish ties with their mother or the mother substitute. Gradually, thereafter, they go on to develop relations with other people in their usual surroundings, and to experiment with social life. This socialization process begins with normal expressions of jealousy, rivalry and even aggressiveness. The child shows increasing interest in other children, and begins to play with them, in a very self-centred way at first, then increasingly collectively, after age 2 years. Socialization truly begins at this age.

After age two, children begin to share, to show affection for people other than their mother, to take increasing interest in others, and in exchanges with them. They are receptive to stimulation and signs of affection from people outside their family.

Children's social and emotional development is thus entirely dependent upon the people around them, and above all on their exclusive relationship with their parents or parental substitutes during the first two years of life. Their affects and the desire to communicate are major motivations in learning to speak. This mental attainment is absolutely inseparable from the social, cultural and emotional context in which children live.

A child who is always alone does not learn to speak, and his or her ability to learn a spoken language declines with time. Observations of "wild children" who lived with no human contact, or of children who suffered brain damage in the regions directly involved in speech show the impossibility of learning to speak after the age of 8-10 years. Conversely, speech is a prerequisite for many exchanges with others, and for learning many things. It is a decisive moment in the child's development.

METHODOLOGICAL DIFFICULTIES

Many investigations have dealt with the ways in which malnutrition during the first years of life influences future development : all raise methodological issues. The definition of malnutrition differs from one author and country to another, and neither nutritional rehabilitation methods nor the criteria for recuperation are standardized. The main difficulty in these studies resides in the complexity of the phenomenon examined — development — and in the number and interaction of the factors involved in this process.

EFFECTS OF MALNUTRITION ON THE BRAIN : VALUE AND LIMITS OF EXPERIMENTS ON ANIMALS

Efforts to define the effects of malnutrition on the brain structure date back to the beginning of the century. Such research should be viewed in the context of studies of the anatomy, histology and physiology of the nervous system in general.

The anatomy and histological structure of the brain are now well known. The specialized function of each part of the brain has been established quite accurately. The projection of the different areas of the central nervous system onto the peripheral level has been clearly defined. These findings are the result of experiments on animals and the observation of neurological pathology in human beings (for example : the representation of the body in the motor cortex, cf figure 2).

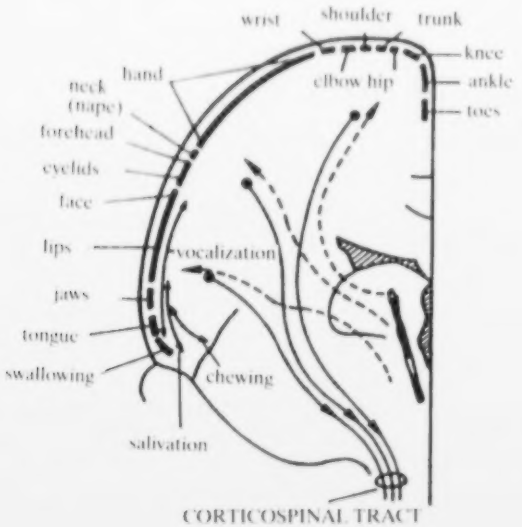
Our understanding of the physiology of the nervous system has constantly been modified by the rapid progress made over the past two decades, with the discovery of the role of the neuro-transmittors (biochemical substances required for the transmission of the nerve impulses through the synapses), a better understanding of vigilance, etc. And yet, the complexity of the central nervous system is so immense that present avenues of research seem to be only at the gateway to an infinite field of investigation. Little is known, for instance, of the mechanisms susceptible of impairing the "higher" mental functions (consciousness, symbolic functions, intellectual abilities) in the absence of any organic damage. This is the problem encountered in the definition and treatment of mental deficiencies and psychiatric pathology. Genetic factors definitely play a role, as does physiological dysfunctioning. Environment, and more specifically the emotional atmosphere and the quality of stimulation during growth, are also decisive.

With the exception of some known organic conditions, it is extremely difficult to assert the existence of a causal relationship between anatomical anomalies of the brain and behavioural disturbances. Furthermore, considerable individual differences seem exist in this respect.

There is no evidence, in humans, of any anatomical modifications of the brain caused by malnutritibn. Autopsies of the brain of many children with fatal acute malnutrition show a decrease in the weight of the brain and the number of cells, as well as a drop in protein and phospholipid content. No conclusions may be drawn from these findings, however, since the interval that necessarily separates the time of death from brain microscopy totally modifies the quantitative biochemical and histological data. In addition, undernou-

rished children do not die of malnutrition only, but of infectious diseases as well, so that the effects observed on the brain cannot be attributed to dietary insufficiency alone.

Figure 2 - Representation of the body on the motor cortex



The full lines represent the fibres of the corticospinal tract (essentially the pyramidal tract). The dotted lines show the sensory afferents. Note the close proximity of motor efferents and sensory afferents.

Note the special place of organs involved in manipulation and vocalization : it indicates the large number of nerve cells involved in commanding them, and the subsequent possibility of precise control of their motoricity.

Source : W. Penfield and T. Rasmussen.

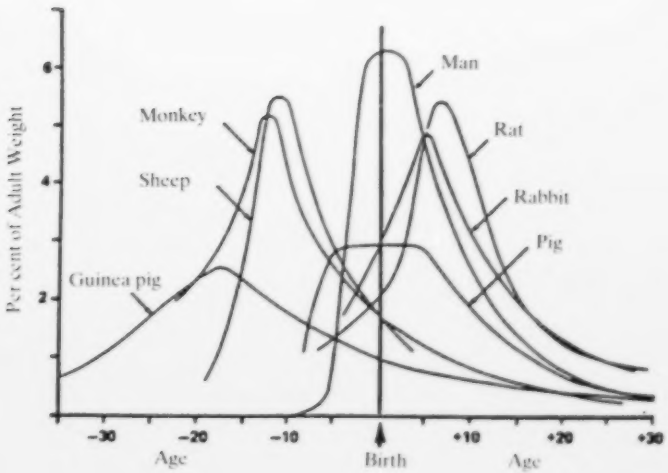
Explorations of the brain of children suffering from malnutrition have been conducted by transillumination of the head, echo-encephalography and computerized tomography. Brain imaging techniques are now advancing extremely rapidly, and will no doubt soon be able to furnish valuable information on the structure and biochemical activity of the brain. For the moment, however, they require extremely costly technical devices and are totally unfeasible for wide-scale use in those countries where malnutrition is prevalent.

For these reasons, it is necessary to resort to animal experimentation to determine whether early undernutrition directly affects the structure of the brain and above all, whether or not such effects may be reversed by nutritional rehabilitation.

Anatomical modifications

In order to study the effects of undernutrition on the development of the brain tissue of rats, the animal is undernourished during the "brain growth spurt". This phase occurs during the first weeks after birth, in contrast to the situation for humans (cf figure 3). The tissues may be examined immediately after the death of the animal, which is killed by an infusion containing a fixative.

Figure 3 - The brain growth spurts



The brain growth spurts of 7 mammalian species expressed as first-order velocity curves of the increase in weight with age. The units of time for each species are as follows : guinea pigs (3) : days ; rhesus monkey (1) : 4 days ; sheep (9) : 5 days ; pig (2) : weeks ; man (5) : months ; rabbit (8) : 2 days ; rat (4) : days. Rates are expressed as weight gain as a percentage of adult weight for each unit of time.

Many errors may be committed in the microscopic examination of the sections, both in counting the cells and their dendrites and in calculating the number of synapses. The tissue shrinkage induced by slide preparation, the thickness of the section, the type of microscope used and the unit chosen for counting the neurons must all be taken into account. Only stereological methods, which are complex mathematical and statistical procedures, provide an extrapolation of the three-dimensional spatial arrangement of the nerve cells and their innumerable connexions, based on the findings collected by the observation of a two-dimensional histological section.

The appearance of the brain is examined under microscopy following undernutrition and renutrition periods of varying lengths, and the results are compared with control groups of normally fed rats.

Often the modifications observed are not statistically significant, owing to an insufficient number of animals studied. Further, the histological techniques used are extremely delicate, which means that the results of many existing studies are not very reliable.

Allowing for these reservations, the main studies performed on animals following undernourishment during the post-natal period show the following modifications :

— a small brain, but normally proportioned to the body, which is also smaller than usual ;

— the cerebellum is proportionately smaller than the rest of the brain. Histological examination shows some groups of cerebellar cells to be more affected, quantitatively, than others ;

— cortical neurons are less numerous in some layers, their density and the appearance of their dendritic spikes are modified ;

— the synapse-to-neuron ratio is considerably reduced in some parts of the frontal and cerebellar cortices ;

— the cerebral fat content is lowered, even when the smaller size of the brain is considered. The distribution of the different fats is modified, especially that of myelin. The distribution and role of other nutrients has not been clearly elucidated ;

— biochemical modifications on the neuro-transmittor level have been observed, but no conclusions may be drawn from this as yet, for lack of proper standardization of measurements.

In summary, malnutrition in rats during the brain growth spurt does not produce highly significant local damage or major physiological impairment. Nonetheless, the expected number of brain cells for the animal's age is not attained, and difficulties in the establishment of connections and exchanges with other cells are noted. There does seem to be a quantitative deficit in the cells count, resulting in distorted interrelations between these cells.

The extrapolation of these results to human beings is extremely difficult, since the timing of brain growth in most laboratory animals differs from that of humans. Their period of vulnerability does not occur at the same time, then, and furthermore experimental methods of undernourishment are not comparable to the human situations encountered. In a slow-growing species such as the human one, deprival of food for several days during the brain growth spurt does not seem to suffice to modify the brain. Nutritional deficits would have to continue for much of the vulnerable period in order to affect the anatomic development of the central nervous system.

Behavioural modifications

Do the neuro-anatomic modifications observed result in functional disturbances within the brain ? If so, what effect do they have on future development ?

In animals, the modifications in the morphological structure of the brain observed following undernourishment go hand in hand with behavioural disorders :

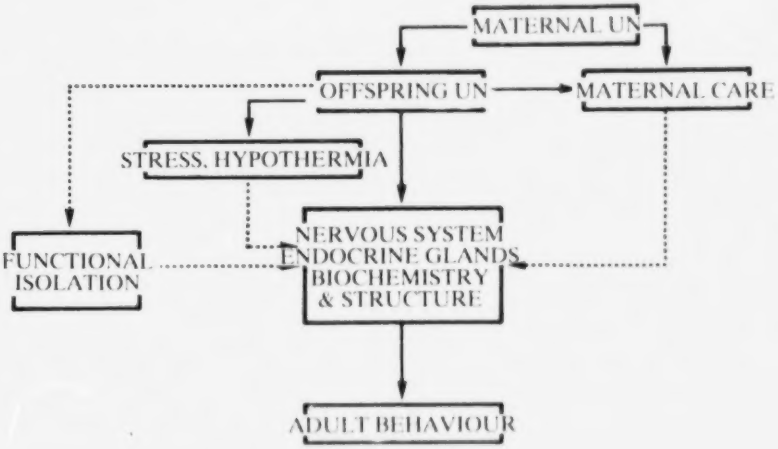
— under-fed rats tend to react more strongly to harmful stimulations (electric shocks, loud noises), and to deprival of water and food. This seems to be linked with an endocrine mechanism that is unable to control the adrenocortical response ;

— their degree of activity and reactivity to social contacts is greater ;

— the relations between the mother and her undernourished offspring are modified, contact with the mother is intensified.

The effects of malnutrition on animal behaviour are necessarily limited to relatively simple types of behavioural adjustment. Some aspects of affective behaviour, learning and memory may be shared by most mammals, but where environmental factors are involved, the human situation is unique (cf figure 4).

Figure 4 - Possible mediating factors between undernutrition of mother and young and ultimate effects on offspring behaviour



Source : DOBBING J. Early Nutrition and Later Achievement. London Academic Press, 1987.

The effects of malnutrition on animals may be studied throughout their lifetime and even in their offspring. Paradoxically, chronically malnourished rats live particularly long, and the occurrence of age-linked diseases is delayed. For some still unknown reasons, the effects of malnutrition on growth, development and reproduction are seen in the first generations, after which they disappear.

Reversibility of disorders

Are brain modifications induced by malnutrition permanent ?

According to K.S. Bedi, adequate nutritional rehabilitation may eliminate most anatomical and histological modifications of the brain, with the exception of weight deficits and numerical insufficiency of cerebellar granule cells.

This anatomical recuperation observed in animals cannot be extrapolated to humans, since the food supplementation methods are not comparable : the action of numerous social and environmental factors specific to human beings cannot be reproduced experimentally on animals.

Great caution must be used in extrapolating from findings on animals to humans. However, experimentation on animals is valuable in that it suggests certain hypotheses for use in guiding research in man. For example, D.E. Barrett takes certain behavioural modifications observed in several species of mammals following undernourishment (attentional impairments, lack of social responsiveness, emotionality, avoidance of new stimuli, reduced exploration of the environment) as hypotheses for the examination of a series of similar behavioural problems in children.

DIFFICULTIES IN FIELD WORK

Great methodological difficulties are encountered in conducting field studies of the effects of malnutrition on child development, owing to the numerous factors to be taken into account, their interactions and their variability.

Investigators must determine what to measure, how, in what group of children, at what time, for how long. They may choose to passively observe a group of children, to intervene actively through experimental situations or testing.

Retrospective studies refer to past events : they are based on memory. All of the events have already occurred when the study is begun. Such investigations are descriptive, and findings are observed under natural circumstances and analysed on the basis of certain factors known as "exposure" factors.

Prospective studies, or longitudinal studies, investigate a group of individuals from a given moment on, for a variable period of time. They may be used to watch for the occurrence of specific events, and to act on these by varying certain factors.

A great many protocols exist for these studies, and none is exhaustive. To understand the complexity of this field of investigation, the reader should be familiarized with a few of the difficulties facing specialists in this field.

Psychometric tests and the problem of measurement

Intelligence quotients

At the beginning of this century, psychologists began to take interest in measuring "intelligence". The first measurement, devised by Alfred Binet in 1905, was based on the calculation of the average of a number of scores obtained on a great variety of tests (arithmetic, deduction, etc) in order to define a scale of aptitudes with respect to age and scholastic achievement.

Later, Charles Spearman introduced "factor analysis" of intelligence. Having noted that a child who succeeded in solving one problem had an excellent chance of succeeding with another, and vice versa for failure, he defined a single factor shared by all cognitive tests. According to Spearman, this factor G (for general) represents an accurate evaluation of the degree of intelligence, defined by him as "mental energy", ability to reason and capacity for adjustment. He views success at a given task as conditioned by a general aptitude shared by all tasks, combined with a specific aptitude to address oneself to each particular task.

In some tests, factor G is preponderant, while in others, such as those involving motor skills, language or memory, specific factors prevail.

The Intelligence Quotient (IQ), is a score measured by the test developed by Wechsler in 1949 ; it reflects factor G. Since then, a whole range of tests have been devised to measure IQ, and these continue to be used to evaluate children's ability to adapt and to learn, considered as the necessary prerequisites for the future development of their intelligence.

However, the IQ is only a figure representing the individual's place in an arbitrary, mathematically constructed system. Its measurement is built on one basic assumption and only reflects a portion of mental capabilities, along with a prediction of adaptability to tasks corresponding to a given scholastic achievement model. It does not take into account the non-cognitive aspects of the personality such as emotional characteristics, types of interpersonal interaction and social adjustability in general. These variables are nonetheless interrelated with the IQ : for example, a strong emotion may make an individual incapable of reasoning. Further, the tests used refer to a European or North-American social, political and cultural context which is quite foreign to the settings encountered in developing countries.

Use of the IQ is therefore quite insufficient for the exploration of some spheres (memory, perception, attention) and for an analysis of social and emotional behaviour that takes cultural specificity and overall development at each stage of life into consideration. It was extensively used in the 1960's to evaluate the development of undernourished children, but its exclusive use as an indicator is now increasingly abandoned. It must be interpreted in conjunction with other variables such as socio-economic status, family size, etc.

In measuring mental capability, all of the many factors influencing children's overall development must be taken into account, through the use of appropriate indicators. IQ is only one of a number of variables.

Other tests have been devised to measure aptitude for reading, or speech, measurement of visual memory or the acquisition of the ability to discriminate, for instance. These tests

class individuals according to their responses to model situations, as compared to established norms. They deal exclusively with aptitudes (cf Appendix 1, glossary of the main psychometric tests).

In the 1960's, a great many studies devoted to the effects of malnutrition on children's mental development were published. These are now criticized for having based their measurements mainly on performance on a standardized intelligence test.

The concept of "social competence"

A new school of thought appeared in the 1970's, which considered "social competence" to be more important than IQ as a criterion for evaluating child development. This concept includes social-emotional and motivational characteristics such as :

- outerdirectedness and degree of imitation in problem-solving ;
- positive responsiveness to social reinforcement ;
- self-control ;
- effectance motivation ;
- ability to get along with other children ;
- ability to adapt to interesting new situations.

A number of investigatory methods have been suggested for measuring the many aspects of mental development. Hurwitz has grouped assessment procedures into six categories :

- developmental scales ;
- tests of general intelligence ;
- neuropsychological test batteries ;
- Piagetian scales ;
- measures of single aspects of behaviour ;
- measures of social-emotional development.

Each of these tests is valuable in its own right, and all are complementary, provided the variable measured is correctly defined.

Defining the variables

D.E. Barrett, an investigator who works on measuring children's behaviour, claims that everything is measurable provided the validity of the variables can be proved.

Following an initial definition of variables, derived from a theoretical hypothesis, the investigator attempts to measure these, using qualitative and quantitative values. For a variable to be considered appropriate, the results must furnish an answer to the theoretical question formulated previously, and the individual differences observed for a given variable must have important implications for the individual.

The approach is as follows. The results of studies attempting to identify behavioural modifications subsequent to an episode of prenatal or immediate postnatal malnutrition are examined (cf table 2).

Table 2

Infant studies on behavioural effects of undernutrition

Investigator	Site	Age at assessment	Behaviour impairment
Lester	Guatemala	1 year	Diminished orienting response
Als et al.	USA	first 10 days	Poor motoric processes, low social responsiveness
Brazelton et al.	Guatemala	1 month	Poor motoric processes, poor at eliciting social responses, lethargic, difficult to arouse
Mora et al. Herrera et al.	Colombia	15 days	Irritability Poor frustration tolerance ; slow visual habituation*
Chavez and Martinez	Mexico	1 year	Frequent crying, clinging ; high dependency
		18 months	Low activity, infrequent playing
Rush et al.	USA	1 year	Short daration of play ; slow visual habituation
Zeskind and Ramey	USA	3 years	Withdrawn ; anxious*
Graves	India, Nepal	1-2 years	Reduced exploration

* These studies also showed significant effects on measured intelligence at age 3.

On the basis of these findings, D.E. Barrett develops hypotheses for the definition of certain variables which seem to be affected at school age in case of early malnutrition, and which may therefore be modified by providing a proper diet (cf table 3).

Table 3

Hypothesized effects of chronic undernutrition at school age

Infrequent happy affect
Timid or anxious behaviour
Low social involvement
Erratic activity level
Poor impulse control
Poor frustration tolerance
Low exploration
Withdrawal from competitive situations

To measure these variables, he uses a number of methods :

— naturalistic observation, the objective of which is the quantification of specific behaviour categories during free play in small groups : for instance, aggressiveness will be measured by the frequency of hitting other children, sociability by the percentage of outside interventions to which the child responds by speaking, etc ;

— intervention, by collecting responses to specific experimental situations.

In a study of 138 6 to 8 year-old boys and girls in Guatemala, he measured the ability to respond constructively to common stressful situations or problems :

— exploration of a new situation ; children are placed in contact with novel play materials and note is made of the latency period before first contact with these toys, the number of materials touched and the level of involvement with individual toys ;
— control of motor impulse : children must clap hands in response to a certain signal and refrain from clapping at other signals. Errors, omissions and anticipated responses are observed ;
— competition : in a relay game with two teams, the children must run to the other end of the room, pop a balloon with their hand and run back to touch the hand of their team-mate. The child's ability to participate in exuberant physical activity and to sustain his or her involvement is observed ;

— situations involving frustration : children are given a small, transparent plastic box containing a prize, but very difficult to open. A count is made of the number of attempts required to solve the problem.

Responses are coded and rated, after which correlations are sought between the facts observed and the reactions produced.

The results show that undernourished children have greater difficulties in tolerating frustration, they tend to be less active and show a lack of initiative and independence.

On the whole, these findings definitely confirm the initial hypotheses as to the effects of early malnutrition on the behaviour of school-age children. These theoretical constructs therefore really are variables ; that is, characteristics that vary from one individual to another and are measurable.

Other investigators have suggested that the mother's attitude to her child's exploration of the object world, the child's attachment to his or her mother, etc, be measured.

The surroundings and family environment are also measurable, using scales taking such indicators as socioeconomic and health status, parents' educational level, etc.

The theoretical hypothesizing of a variable, followed by the establishment of the means for measuring it and for validating this measurement, requires careful consideration of the pattern of child development, including those tasks that are feasible at each age, and children's needs with respect to their parents at different stages of development. If children's developmental level, and their interests and needs at each stage of growth are neglected, the variables generated are unlikely to be useful.

Types of investigations

Retrospective surveys

In industrialized countries

Long-term retrospective studies have been rare so far. One of the best known surveys dealt with the consequences of the famine experienced in some Dutch villages during a 6-month period in 1944-45, that suddenly ended when they were liberated by the allies. Eighteen years later, measurements and tests performed during the medical examination of young recruits beginning their military service furnished an evaluation : no lasting effect on their mental faculties was detected.

Similarly, occasional cases of malnutrition in children with pyloric stenosis or ileal atresia in industrialized countries have been monitored. A relatively short, limited period of decelerated growth (several weeks or months) was observed before treatment. Several studies confirm the existence of perfectly normal mental faculties some years later.

A short-lived dietary insufficiency followed by rehabilitation under optimal conditions does not produce any adverse effects on the brain functions.

However, satisfactory previous nutritional status, a short period of undernourishment and total recuperation in an excellent environment are exceptional conditions, in regard to those observed in underprivileged countries.

In developing countries

The quality of "intersensory integration" may be studied, in addition to the IQ. This is the ability to transfer information perceived in one sensory form to another form. For instance, when a child hears an unusual sound, he or she will visually explore the area from which the sound came. Lowering of the quality of this integration is viewed as a contributive factor to the inability to read and write.

Most studies involving children in developing countries who have suffered from malnutrition show their IQ and school achievement to be diminished, with occasional behavioural disorders evidenced by a decreased attention span, until the end of adolescence. Several retrospective studies of children with marasmus show their mental development to be less advanced than that of other children several years after the episode.

In industrialized as well as developing countries, then, findings are contradictory, and seem to indicate that malnutrition does not suffice in itself to explain long-term developmental modifications in these children.

When the effects of malnutrition are studied several years after the episode, we have no knowledge of what occurred in the meanwhile, and more specifically, during and immediately after rehabilitation.

This type of study does not take into consideration the severity or the duration of malnutrition, nor the quality of rehabilitation. Further, the control group used is generally composed of siblings, for whom there is no assurance that they too did not suffer from malnutrition or emotional deprivation at some time during their growth.

These retrospective studies are therefore not extremely valuable in determining the causal relationships between severe malnutrition and mental development, although they have been useful for the formulation of hypotheses as to the role of environmental factors associated with malnutrition.

Prospective surveys

These are of two types :

• before the occurrence of malnutrition, within an exposed population (an impoverished group with a high prevalence of malnutrition), dietary supplementation is furnished to certain groups during the periods of highest risk :

— during pregnancy only ;
— during pregnancy and lactation ;
— during pregnancy and early childhood.

The results are then compared with findings for control groups within the same population. The advantage of this first type of study is that the initial nutritional status of the groups studied is known.

• on children already suffering from malnutrition, the effects of treatment are investigated using either simple renutrition, or nutritional supplementation associated with psychomotor stimulation over a variable length of time.

Height/age ratio is generally used as an indicator of malnutrition and of long-term recuperation, but many studies do not specify the indicators used to measure children's nutritional status.

The objective of these studies is to isolate the effects of diet from the effects of social, emotional and educational factors.

Several issues are raised by their methodology, however :

— often the randomized selection of experimental subjects is not respected. In practice, the administration of different treatments to children within a same neighbourhood or hospital service, whose families all know each other, is extremely delicate. But if children from different neighbourhoods or hospitals are studied, the environmental factors also vary, and the group is no longer homogeneous ;

— in most studies, the nature of nutritional rehabilitation is not accurately described. The amount of food effectively consumed in comparison with the amount given, the protein and caloric values of foods are not reported ;

— occasionally, the absence of a control group makes any interpretation of findings impossible. When a control group does exist, it is either composed of children from the same social context, for whom there is no assurance that they have not suffered from malnutrition, or of children from a different social context, and the variability of environmental factors must be taken into account.

Further, many biases develop during the nutritional rehabilitation process. These include :

— the fact that children receiving supplements are given special attention may have a

positive influence on their behaviour. When supplements are given to the mother and the entire family as well as to the undernourished child, the family's behaviour toward the undernourished child changes, and the latter's response to those around him or her is modified ;

— in addition to the problem of defining what to measure, there is the problem of examiners. They must be experienced, and be in charge of the same children throughout the longitudinal studies. Their possible influence on children's behaviour must be taken into account. The impact of the social support provided by home visits is inseparable from the effects of stimulation itself ;

— reactions to treatment also vary. Children's initial nutritional status and their usual dietary consumption influence resumption of growth. Supplementation is more effective and weight gain more rapid when the child's malnutrition is more severe ;

— little is known of the influence of age on individual responses to treatment. For physical growth, response to supplementation peaks during the last three months of pregnancy and the first three years of life. The effects of psychological stimulation most probably vary with the child's age.

As children grow, variables related to their social environment increasingly influence their mental development. There is every reason to think that stimulation is less effective during the first year of life than at a later period. Furthermore, the short-term results obtained by stimulation are rarely followed up by later evaluation.

The mechanisms by which dietary supplementation and psychomotor and emotional stimulation influence children's development, as well as their interaction with others, have not been elucidated.

In one hypothesis, the explanatory mechanism is the level of activity. The classical picture of severe protein-energy malnutrition, describing it as combining "apathy, sadness, withdrawal, etc, is the expression of a low level of activity. These children respond feebly to outside stimulation ; as a consequence, they receive qualitatively and quantitatively inferior information and their mother's receptiveness is modified. This has a negative impact on their development during this period.

According to some authors, the functioning of the brain is not modified during episodes of malnutrition by anatomical or biological transformations, if these exist, but by the adverse effects of the mental disorders linked with malnutrition itself.

This lowered level of activity is a constant in undernourished children. It may be observed earlier than deceleration of growth, as measured by the height age ratio.

In this explanation, low caloric intake, leading children to limit their expenditure of energy, first affects their level of physical and mental activity. This then produces a considerable decrease in receptiveness to outside stimulation, thus substantially restricting development. Protein deficiency, on the other hand, is believed not to affect physical growth.

In New Guinea and Uganda, studies of children rehabilitated following severe protein-energy malnutrition furnished material on the comparison of two groups : predominantly protein-deficient malnutrition of the kwashiorkor type, on the one hand, and cases of marasmus or of chronic malnutrition with insufficient energy intake on the other.

The former, who showed behavioural disorders typical of kwashiorkor, had normal mental development subsequent to recovery.

Development disorders persisted in the latter following nutritional rehabilitation, probably because of a prolonged decrease in their level of activity during the period of energy deficiency.

Seemingly, then, the behavioural disorders observed during kwashiorkor, classically believed to be caused by protein deficiency, are temporary and have no consequences for future development.

Basing their work on this hypothesis, other investigators have attempted to prove that energy supplementation of severely undernourished children prevents future developmental disorders by increasing their present level of activity, while protein supplements only affect their physical growth.

However, the level of activity hypothesis has not been confirmed, owing to the small number of cases studied and the difficulty in classifying protein-energy malnutrition with respect to the type of deficiency and its duration.

Methodological difficulties in establishing correlations between malnutrition and development make it difficult to draw any conclusions. However, it does seem that the development disorders resulting from early malnutrition may be compensated by appropriate treatment. Most studies provide evidence of the major role played by the environment. Present research tends to move in this direction, with attempts to demonstrate the links between malnutrition, development and environment, three multifactorial spheres.

Intervention-type investigations

The objective of these studies is to develop compensatory programmes in the field of nutrition, as well as of health, education and hygiene, in an attempt to measure the respective contribution of each of these sectors to children's development.

Intervention-type studies aim at clarifying the cause of retarded development. They attempt to distinguish the effects of nutrition from the influence exerted by socioeconomic level, living conditions and education.

- Effects of nutritional supplementation according to age and duration of action

  — In population groups exposed to malnutrition

Supplementation for mothers during pregnancy

No study of this type has been conducted in any developing country. In New York, supplementation of a group of pregnant black ghetto women particularly exposed to the risk of malnutrition had no effect on the psychomotor development of their children at age one year. In Montreal, the administration of a supplement to a group of pregnant women had scarcely any beneficial effect on the children's performance at school.

Supplementation for mothers during pregnancy and lactation

A double blind study performed in Taiwan has shown that supplementation administered during pregnancy and lactation had a small but significant influence on eight

month-old children, as evaluated by the Bayley Test (exploration of sensori-motor development and language). The improvement mostly affected motor achievements.

Supplementation for mothers during pregnancy and for small children

In Bogota, pregnant women who already had undernourished children were randomly assigned to four groups.

The first group was given a dietary supplement throughout pregnancy. Following delivery, the child was given supplementation until age three years.

In the second group, no dietary supplement was distributed, but children were given intensive psychomotor stimulation during their first three years.

The third group benefitted from both types of treatment : dietary supplementation during pregnancy and the first three years, along with psychomotor stimulation.

The fourth group received no treatment.

At age 18 months, the treatments given to groups two and three were found to be beneficial : performance on all subscales of the Griffiths test improved significantly, with the exception of language. At age 36 months, a difference with respect to language tests also developed, to the advantage of the stimulated groups. The effects of stimulation then subsided with age.

There were two additional groups formed : one received supplementation throughout gestation and up to the age of 6 months, the other from age 6 to 36 months. Whereas supplementation affected the positive activity level of 4 month-old children, particularly those who were stimulated, no major effect of supplementation was observed at the age of 8 months.

In Guatemala, four villages participated in a nutritional supplementation project. Two were given a protein-rich drink (ATOLE), the other two a calorie-rich drink (FRESCO). Supplementation was voluntary ; the villagers decided whether or not to consume the drinks. A significant correlation was found between the amount of supplement consumed and children's cognitive functioning. Until age three years, the supplement mostly improved motoric and manipulative skills, rather than linguistic and cognitive abilities. After age three years, language development showed most benefit. These effects were small, however, and no complete analysis of the findings has yet been published.

In South Africa, 14 children born into "at-risk" families with one previous childhood case of kwashiorkor were given supplementation from the age of 2 months to 28 months. At age 9 years, their mean IQ was 10 points higher than that of older, non-supplemented siblings who had never suffered from kwashiorkor.

In Louisiana, 21 children who received supplements from the intrauterine period on, for an average of 56 months, were compared with their older siblings, supplemented only after one year of age, for an average of 31 months. At the ages of 6 and 8 years respectively, a difference in IQ of 13 points was observed on the Wechsler scale (WISC).

- In undernourished children

In one Mexican study, J. Cravioto bases his definition of adequate diet on three criteria :

— a physiological criterion based on the nature of the nutrient and its caloric value. Its function is to provide the nutrients required for growth, functioning and the regulation of metabolism ;

— a "psycho-physical" criterion, sensory stimulation, for which the unit of measurement is the organoleptic properties of food, which provide the organism with stimuli (texture, colour, smell, taste, temperature, etc). This dimension takes into account the stimulation induced by the external appearance of food, as well as its nutritive value ;

— a "psycho-social" criterion taking meal-eating as the unit of measurement. This function of food includes all of the values attributed to food by the family and society : it may be a reward, punishment, an experience linked with a gratifying person, identification with an ethnic or cultural group. Secondly, mealtime provides an opportunity to define each individual's role within the family and society : who presides over the meal ? Who gets the best portion ? Who directs conversation ? It is also a medium for the expression of the emotional bonds and the tensions prevailing between members of the family.

These examples illustrate the extremely broad role played by eating.

When a small child is deprived of food, the deprivation extends far beyond a lack of the nutrients required for physical growth, to the deprivation of sensory stimuli and of social and emotional experiences. The latter two dimensions of eating are not often taken into account in the rehabilitation of undernourished children.

J. Cravioto's investigation deals with 36 severely malnourished children under 6 months of age when admitted to a hospital service for intensive renutrition. All showed severely retarded height and weight along with a psychomotor development far below average. Following emergency treatment and the elimination of electrolytic disturbances and infections, the children were randomly divided into two groups.

One group was given the department's routine renutrition treatment. The other had the benefit of psychomotor and emotional stimulation as well, through several daily sessions conducted by specially trained workers who placed particular emphasis on language.

Although the first group did not receive "planned" stimulation, it did of course receive attention from the personnel through the dispensation of the routine treatment. There is always an "inherent stimulation" produced by the bonds that gradually develop between the children and the personnel.

The results show that 70 to 90 % of children in the stimulation programme regained a normal level for their age on Gesell's development scale, as compared to 30 % in the other group.

Other studies dealing with older children have confirmed these results and shown that the difference between the control group and the group of stimulated children may persist for several years.

INTERACTION BETWEEN MALNUTRITION, DEVELOPMENT AND ENVIRONMENT

ROLE OF THE ENVIRONMENT

The environment is defined as including everything that makes up the context in which children live : their family, and more broadly, the community to which they belong. The quality of this environment depends on many factors : family structure and social organization, hygiene and health status, socioeconomic situation, customs, educational level, types of relationships and emotional atmosphere, etc.

In most studies, there is a tendency to attribute the poorer performances observed in malnourished children to either physiological factors or to environmental factors, with no consideration of their possible interactions. It is a fact, however, that poor hygiene and repeated episodes of infection, or again, a break-up of the mother-child relationship, contribute to the development of malnutrition. Once it has occurred, this state of malnutrition may be prolonged and aggravated by living conditions (poor hygiene, family problems), thus creating a vicious circle.

In most cases, once malnutrition is cured, the living conditions remain the same and continue to disturb the child's development by acting either by themselves or in conjunction with a poor diet. This leads to relapses, a well-known occurrence in hospital services specialized in the treatment of protein-energy malnutrition.

STUDIES BASED ON OBSERVATION

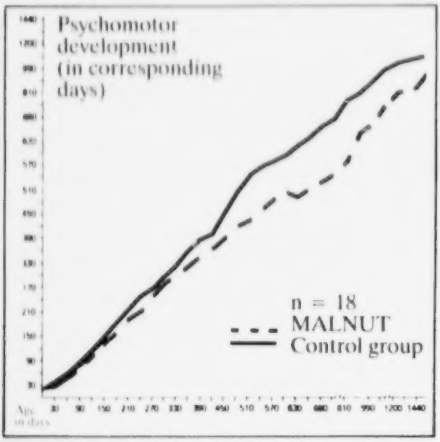
Interaction between malnutrition and development

In a Mexican study conducted by J. Cravioto and E.R. Delicardie on 334 neonates randomly selected within an "at-risk" milieu, 22 cases of severe malnutrition occurred between the ages of 4 and 53 months, including 15 cases of kwashiorkor and 7 of marasmus. Anthropometric measurements at birth did not show any significant differences between the future undernourished and the others.

Motor development was evaluated in all children once a month from birth to age 4 years, using the Gesell scales.

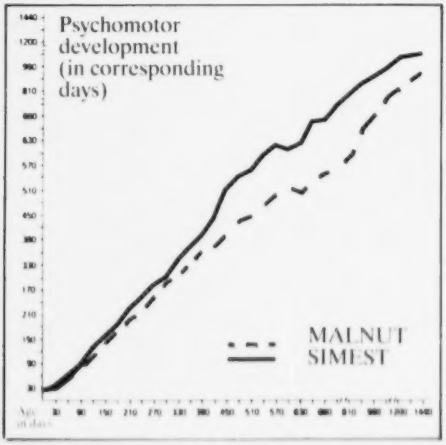
In the control group, the relationship between motor development and chronological age may be described by a single, rising, straight line. In the undernourished group, psychomotor development is normal during the first year, then slows down during the second year, after which it draws closer to the normal curve (cf figures 5 and 6).

Figure 5 - Mean psychomotor development values according to age in children with severe malnutrition and randomly-selected controls



Source : DOBBING J., CRAVIOTO J. Nutrition and brain development. Annales nestlé. 1980 ; N° 44. 55 p.

Figure 6 - Mean psychomotor development scores according to age in children with severe malnutrition and controls with a matching score for home stimulation



Source : DOBBING J., CRAVIOTO J. Nutrition and brain development. Annales Nestlé. 1980 ; N° 44. 55 p.

In a study conducted in Jamaica by S.A. Richardson, 71 boys aged 6 to 10 years who had suffered from severe malnutrition during the first two years of life were followed up, along with 71 boys of the same age with no history of malnutrition. IQ at school age, taken as one indicator of mental development, is viewed with reference to the following :

— presence or absence of a state of severe malnutrition during infancy ;

— the children's height at the time testing, as reflecting chronic, prolonged malnutrition. Height is the best indicator of past nutritional status ;

— their current social status, as estimated by the parents' capability, home economic conditions and the amount of intellectual stimulation received by the child.

Taken separately, early malnutrition, small stature and insufficient stimulation are each strongly correlated with a low IQ. The coefficient of multiple correlation between IQ and these three variables shows social stimulation to be the factor most closely linked with IQ, followed by height, and last, hospitalization for a state of severe malnutrition during infancy.

The extreme groups are composed of children with all three risk factors, on the one hand, and by those with none of these factors, on the other hand. The 25.5 point difference in average IQ between these two extreme groups (49.4, as against 74.9) is quite significant.

In children with a history of malnutrition but satisfactory height and a good social status when tested, the mean IQ is only slightly lower than that of controls (- 2 points). By contrast, the mean IQ of children with unsatisfactory height and an underprivileged social status is much lower than that of controls.

In conclusion, an acute episode of malnutrition during the first two years of life has little influence on intellectual development provided socioeconomic conditions are favourable. Conversely, early malnutrition does influence the level of mental attainment at school age when the social setting is not conducive to development.

In another study, Korean children adopted by families in the United States were followed up. Some of these children were known to be definitely undernourished (weight below the 3rd percentile) at the time of adoption, others were moderately undernourished (weight between the 10th and the 25th percentile), or again, well fed (weight above the 25th percentile). All were examined 4 to 13 years after adoption, at a time when their weight was comparable, and satisfactory for their age. All had a level of performance at least equal to that of the North-American children of the same age used as control groups.

In the well-fed children, however, the results of a number of psychometric tests at adoption time were higher than those of moderately undernourished children, which in turn were superior to those of the previously undernourished.

It does seem, then, that a good environment may counterbalance the effects of early nutritional deprivation.

Interaction between environment and malnutrition

A study conducted in the Barbados by J.R. Galler compares two groups :

— 129 children suffering from protein-energy malnutrition (Weight/age below 75 % of normal) during their first year ;

— 129 control children from the same socioeconomic milieu, whose weight for age had always been normal.

The children were examined between the ages of 5 and 18 years (tests for growth, development and behaviour). Follow-up of the social environment during infancy and thereafter was done concomitantly.

The group of children with a history of protein-energy malnutrition showed deficiency in five social characteristics :

— level of hygiene ;
— family stability ;
— means of transportation used ;
— the child's actual experience at home ;
— mother's educational level.

Throughout the study, undernourished children were found to have significantly deficient responses to psychometric tests for IQ, performance and language. Statistical calculation of variance shows the factors linked with environment to influence intellectual performance in these children, regardless of their past nutritional history. The same results are found in the analysis of attention disorders in the same children.

Both nutrition and environment influence children's intellectual achievements, with each factor acting independently.

Mother-child interaction

In a study conducted in Mexico, J. Cravioto and E.R. Delicardie followed up 334 children born the same year in a poor village. 22 of them developed serious malnutrition during their first three years of life. These 22 children are compared with 22 other children from the same cohort. The socioeconomic status of both groups of families was similar.

The value of this study resides in its evaluation of family environment before the occurrence of malnutrition :

— homes in which children developed malnutrition had lower scores than controls with respect to the quality and quantity of social, emotional and cognitive stimulation ;

— during the first year, the mothers of the 22 future undernourished children took less interest in their child's performance than did the control mothers. They were less receptive and less sensitive to their child's needs. They tended to communicate less through speech, and showed less emotional involvement.

This is a unique study, and no conclusions may be drawn for other cultural settings.

Mention may be made of findings from several other studies on the mother-child relationship during or after an episode of childhood malnutrition :

— mothers often react to their child's malnutrition by increasing the amount of physical contact and the number of feedings. However, these children do not play much, and seek little spontaneous interaction with their mother, although they spend far more time at the breast than control children of the same age. Mothers tend to overprotect their undernourished child and to provide less stimulation. This was seen in India and West Bengal ;

Cultural differences do seem to be at work here, however, for the same study, conducted in Nepal, did not find any difference as to the number of feedings or any modification of the mother-child relationship in malnutrition, as compared to controls.

— in Mexico, dietary supplementation of children at risk of developing malnutrition and of their mother did modify mother-child interaction. The mothers of non-supplemented children spent 50 % of their time establishing physical contact with their child, as against 20 % in the supplemented group. Mothers of supplemented children ceased to be overly protective, and encouraged their child to be more exploratory and independent.

In one study, lower mean IQ's were found in a group of mothers of undernourished children in comparison with a control group of mothers of healthy children.

A study comparing a group of undernourished children to a control group showed that families of undernourished children tended to be more unstable than others (single mother, father and mother often absent, poor family relations, etc).

In another investigation of the same type, the family situation (stability of the parental couple, educational level, socioeconomic status) was found to be more unsatisfactory in a group of undernourished children than in a control group. However, a comparison between the mean IQ of the two groups of mothers did not show any difference.

On the whole, these studies seem to prove that the underlying family situation does play a role in the occurrence of malnutrition and in the child's ability to recover.

Mothers' reaction to their child's malnutrition - increased physical contact and longer duration of feedings - may be a means of protecting the child and compensating for malnutrition and biological deficiencies. On the other hand, this over-protection seems to momentarily slow down the socialization process, so necessary to development, by decreasing receptiveness to outside stimulation.

However, mothers' reactions are influenced by their cultural and family environment.

RESEARCH ON RELATIONS BETWEEN POVERTY, GROWTH AND DEVELOPMENT : THE CALI EXPERIENCE

In Colombia, the tremendous rural exodus of the past two decades has considerably increased the urban population. "Poverty Belts" have grown up around most of the country's large cities in recent years. In the overcrowded slum areas, living conditions are extremely precarious, public services such as water supply, electricity and sewerage systems are insufficient for the needs of the population, and health and education services are both scant and of low quality.

Crowding, promiscuity and unemployment are the daily lot of slum dwellers. They cannot afford more than a mediocre diet on their meagre income, and the unhealthy environment constitutes a perpetual threat to health. Poor diet, compounded by a lack of hygiene, creates a vicious circle most propitious to malnutrition. Further, people under the greatest physiological stress - pregnant women, small children and adolescents - are most vulnerable. Broken homes are frequent. The obligation to work outside of their home forces women to leave their children unprotected and unattended, for lack of preschool establishments.

Hopelessnes and defeat are the predominant feelings within this group. These misfortunes are quite prejudiciable to children's psychological balance and cause them to become hostile, unsociable and aggressive. When they reach the age of 7, their first school year is often a failure.

L. Sinisterra heads a group that runs a nutrition unit in a suburban Cali hospital. This unit contains a nutritional recovery ward operated jointly with the Paediatric Department of a University Hospital. During the early years, its research activities mostly dealt with the physiopathology of malnutrition. In the course of two years, over 100 cases of severe malnutrition were treated, 70 of which suffered relapses within a matter of months. Most of these children lived in the slum area near the hospital. This finding brought the team to leave the hospital and establish its headquarters in a medico-social centre located in the heart of the community to which the undernourished children belonged. A nutritional rehabilitation and education unit was created, in which an inexpensive weaning food named Colombiharina, made of locally produced raw materials, was promoted.

The outcome was positive with respect to the recuperation of nutritional status. Regular, prolonged follow-up of the children subsequent to their recovery, brought the relapse rate down. However, the health workers found that although their physical recuperation was satisfactory, most of the children who had suffered from malnutrition were socially, psychologically and emotionally retarded. Five and six year-olds acted like two or three year-old toddlers. The team's presence in the neighbourhood had brought them to know the childrens' families, and they sought to isolate those factors that hindered development.

This study is valuable in that it corresponds to the concerns of field workers faced with real life situations. Its goal is the discovery of concrete strategies capable of reducing the physical and psychological consequences of malnutrition to a minimum, and the application of these strategies through work in a medico-social centre.

Two objectives were set by this group :

— the identification of the types of action, such as long-term nutritional supplementation, psychomotor stimulation and medical care, capable of eliminating the negative effects of malnutrition in small children. Can supplementation and stimulation overcome these children's retardation ? If so, until what age ?

— to determine the relationship between the specific disorders caused by an episode of malnutrition in early childhood and cognitive and social performances at school age.

To achieve these objectives, it was necessary to define tools for :

— identifying the specific aspects of mental development affected by nutritional deficits, as well as by detrimental environmental and health factors ;

— identifying those disorders affecting different aspects of development which can be corrected ;

— determining how these modifiable or permanent disorders influence children's future development.

Measurements were taken, using a series of tests and scales specially developed for this group, in order to evaluate the cognitive and social-emotional development of children at the time of the episode of malnutrition, and to serve as a variable for the estimation of their future success or failure at school.

The experimental design adopted involved action in the field of nutrition (supplementation), health (care and prevention) and psychological/affective behaviour (stimulation) so that the effects could be directly evaluated.

Selection of the groups to be studied was based on :

— one criterion for the family's low socioeconomic level (average monthly per capita income of five dollars) ;

— criteria for chronic malnutrition and "poor health" of children :

- weight and height below the third percentile, using the Boston norms ;
- an average of 10 clinical signs of chronic malnutrition ;
- presence, on the average, of five to six dental caries. In addition, 10 % of the children selected were exposed to tuberculosis, 50 % had a recent history of diarrhoea and chronic vomiting, 75 % had a high intestinal parasite count and 15 % suffered from extensive skin infections.

The following treatments were administered :

— nutritional supplementation (NS) ;

— health care (HC) ;

— cognitive stimulation (CS) centred around speaking, as well as classification and the generalization of objects and concepts ;

— physical stimulation (PS) through sustained motor activity ;

— low stimulation (LS), based on the spontaneous use by children of playthings provided without any special educational context.

In the first pilot study, four groups of children were defined ; each received a different treatment :

- group 1 : NS + HC + CS
- group 2 : NS + HC + PS
- group 3 : NS + HC + LS
- group 4 : controls (siblings of treated children) who received no treatment.

Four months later, the different groups had reached similar levels of physical and nutritional recuperation.

Group 3, mildly stimulated, had progressed no more than the control group, according to cognitive development tests.

The results of groups 1 and 2, which had benefitted from cognitive or motor stimulation, were comparable to those of group 3 on the basic cognitive tests and better on the verbal tests.

Stimulation, be it of a cognitive or a motor type, had essentially improved the ability to perform specific tasks rather than overall intellectual capability.

In a second pilot study, six groups were defined :

- group 1 : undernourished children, NS + HC + CS
- group 2 : normal children from same neighbourhood, NS + HC + CS
- group 3 : undernourished children, NS + HC
- group 4 : control group, undernourished children unrelated to tested children, no treatment
- group 5 : control group, siblings of children studied, no treatment
- group 6 : control group, normal children from same neighbourhood, no treatment.

Before the interventions, groups 2 and 6, composed of "normal" children, had better results on tests measuring cognitive development, language and ability to perform certain tasks than children in groups 1 and 3, composed of undernourished children from the same neighbourhood.

At the end of six months of attention, group 3, which had received nutritional supplementation plus health care had the same level of cognitive development as control group 4, composed of untreated undernourished children.

Group 2 maintained its advance over group 1, but with less of a gap than before treatment. Group 1 had better cognitive performances than group 6.

In this second pilot study, social-affective or social-emotional development was also measured. Great caution was used in assigning individuals to each observer, since the observation of affective and social behaviour is highly subjective.

A scale for security-insecurity involved facial expressions, approach versus avoidance responses, vacillation versus consistency responses.

Control groups belonged to the "insecure" tendency, while treated groups seemed to have improved their feeling of security, and group 3 apparently showed a sort of random fluctuation.

A scale for active-passive attitudes showed an improvement in groups 1, 2 and 3, which were more active, whereas the untreated groups had become more passive at the end of five months.

Although these changes in the social-affective sphere may not be permanent, they may well be a consequence of nutritional treatment, even without any behavioural stimulation. By consolidating the child's physiological potency and eliminating the harmful sensory effects of infection and disease, it is probable that ability to respond and receptiveness to learning are enhanced.

In the last analysis, these two pilot studies have shown :

— that children with nutritional deficits associated with other types of pathology are handicapped with respect to certain psychological aptitudes, during the first years of life ;

— these lags in development may be overcome provided action is taken in the preschool years ;

— undernourished children may catch up with correctly nourished peers in their neighbourhood, but do not attain the level of well-fed children from privileged backgrounds.

The conclusions of these pilot studies have served to guide research workers in the conception of a four-year longitudinal study.

The longitudinal study is based on a number of measurements of development. Methodology was improved : a control group of economically well-to-do children was selected, in order to construct local standards for physiological and psychological development, independently of foreign norms.

The table reproduced below shows that the high educational level of parents explains the higher income, and consequently, a better diet. It is interesting to note the relationship between the level of parental education and the environment in which they live.

During the four years studied, some mothers in the socioeconomically privileged group added one or two years of formal education to their average. In the other group, educational level did not change in the course of the study (cf tables 4 and 5).

Table 4

Characteristics of the experimental families in the longitudinal study

Socioeconomic characteristics	Reference group [a] (Nq = 60)	Experimental group [b] (Nq = 300)
Number of persons in house	4.9	7.5
Years education of father	14.5	3.3
Years education of mother	10.4	3.0
Total monthly income (in US $)	560	44
Persons per sleep room	1.2	4.7
Electricity or gas for cooking	100 %	6 %
Potable water at home	100 %	4 %

[a] Upper class children.

[b] Lower class children.

Table 5

Experimental design of the longitudinal Cali project

Groups	Number (1971)	Treatment year				Number (1974)
		1971	1972	1973	1974	
T4	60	CS + NS + HC	CS + NS + HC	CS + NS + HC	CS + NS + HC	53
T3	60		CS + NS + HC	CS + NS + HC	CS + NS + HC	50
T2	60			CS + NS + HC	CS + NS + HC	51
T1	60				CS + NS + HC	50
HS	60	Upper class comparison group				52
	300					256

CS : cognitive stimulation NS : nutritional supplementation HC : health care

Each period of intervention lasted one year. During the preschool phase of the study (children aged three and one half to seven years), action provided significant benefits in the sphere of general cognitive ability. From phase 1 to phase 4, the effects of action were cumulative. The most rapid changes in cognitive development occurred during the first phase, in fact. It seems that the earlier the intervention, the greater the effects are during the first phase. The same trend was seen for physical growth, but it was less clearcut.

Following the first phase of the intervention, the gap between the average performances of socioeconomically privileged control children and those in the experimental group increased.

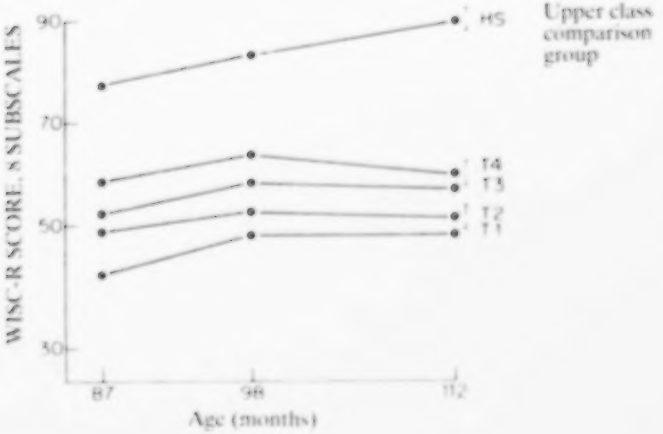
Development during the early years as a variable in school performance

Children in the study were also followed up during the two years consecutive to the longitudinal study, when they all attended the Cali public school system.

Another control group (TO) was formed. It was composed of socioeconomically underprivileged children not involved in the study but who had not suffered from malnutrition, judging by their anthropometric measurements. The lowest scores were nonetheless found in this group before school entrance and after two years of schooling. This finding suggests the existence of major obstacles to normal cognitive development in this underprivileged urban environment, even when the nutrition situation is relatively adequate.

The experimental groups maintained their respective positions, although a plateau was reached after the first year. The difference between children from an underprivileged setting and the others increased (cf figure 7).

Figure 7 - Progress of cognitive development of experimental and comparison groups in the period following preschool intervention



Children's physical work capacity

The longitudinal study evaluated the children's physical work capacity by measuring maximum oxygen consumption (VO2 max). The VO2 max was definitely lower in undernourished individuals. A progressive decline in VO2 max was evidenced in individuals with increasing severity of undernutrition.

Studies have shown a relationship between work productivity and nutritional status in manual workers, through measurement of the VO2 max. Early undernourishment limits development of the genetic potential (height and weight) and the VO2 max. thus limiting the working capacity.

Measurements performed at age 6 years in groups of underprivileged children who were undernourished at age three years and later rehabilitated have shown substantially lower VO2 max levels than in controls. Years of supplementation did not bring the VO2 max up to normal, then, although growth had resumed.

It is interesting to analyse these findings : the limited amount of energy available may explain the diminished physical activity and mental apathy of small children living in underprivileged neighbourhoods. Their curiosity and propensity for exploration are reduced, and contribute to slow down their mental development.

The following conclusions may be drawn from this longitudinal study :

— action on the environment through intervention in the educational sphere has greater impact than nutritional supplementation on the cognitive development of children from underprivileged settings suffering from malnutrition ;

— recovery of cognitive development depends on the duration of the intervention and on children's age. Children who began the programme at a very early age responded better, and showed more lasting progress ;

— when the criterion for the level of cognitive development is school achievement, progress is seen to decline as soon as the intervention ceases, and its effects disappear within some years. Improvement, then, was only temporary.

This study clearly shows that action affecting the environment has some positive but necessarily temporary effects when the intervention is limited in time and is external to the milieu.

The Cali team is now attempting to determine how individuals and communities in the poor parts of the city reacted to the programme. Families' interest in the overall process of child development should be materialized by active, ongoing participation. Pregnant women should be the first group to be sensitized. Above all, women's interest in and relation with the child in their womb, and subsequently with their baby should be intensified, before any other action is undertaken. A strong, warm mother-child bond is the supportive pillar on which the child's development rests, and which may be reinforced by outside help. A deepening of women's understanding of the reproductive process, the course of pregnancy and children's development is a necessary prerequisite to any improvement of children's future.

Having reflected on this, the personnel working at the medico-social centre decided to set up groups of women in early pregnancy. In these, women express their ideas about pregnancy, reproduction, mothering, education, affection and final child development.

Along with these meetings, women are given regular pregnancy check-ups, and nutritional supplementation. It is recommended that mothers gain at least 10 kg during pregnancy, and suggested that they gain a good part of this weight during the first half of pregnancy.

The active participation of mothers and encouragement received from fathers has generated a tendency to entrust them with increasing responsibility for teaching, supervision and actual management of this "extended" programme of mother and child care.

The community seems to take pleasure in learning and participating in this sphere of activity. The team plans to attempt other interventions in the future, taking into account the impact of enhanced community awareness of the process by which its children develop.

CONCLUSION

Early childhood malnutrition is the most widespread pathology in the world. In many countries, the effort to control nutritional deficiencies is a day-to-day concern. Beyond its immediate consequences - mortality and severe morbidity - the sequels left by malnutrition in every sphere of child development require close analysis.

Long-range effects of early childhood malnutrition on physical growth probably interfere with physical working capacity in adulthood, with the risk of reducing the adult's resistance and productive ability. Despite our still limited understanding of how the brain functions, and the difficulties in measuring people's intellectual and adaptative capabilities, a certain number of developmental disorders have been shown to exist in children who suffered from malnutrition during the perinatal and early childhood periods. Observation of children in developed countries and correctly implemented interventions on children in developing countries have indicated that most of these conditions are modifiable, provided action is aimed simultaneously at nutrition and the child's environment. It is important to act over a sufficiently long period of time, while the main mental functions are being elaborated.

The influence of the expectant mother's nutritional and psychological status on the overall development of the child during gestation and the first years of life has been amply proved, both by research programmes and by experimental action. Care definitely must be provided for the mother-child dyad if fuller child development is to be achieved.

Over and beyond physical growth, the child's development is a dynamic process in which action and communication play an essential role. Being a total process, development requires adequate health and dietary conditions, but also a high-quality social-affective milieu if it is to proceed harmoniously. At birth, children possess a certain potential, which is materialized through interaction with their human and non-human surroundings. They require close attention until the age of 6 years, so that they may gain access to the different phases of development : early prevention, during this period, may avoid later disorders. Beyond that point, compensation for earlier deprivations is more difficult.

Malnutrition develops because of insufficient dietary intake, often connected with an underprivileged environment.

In most cases, the deficiency is not solely nutritional, but is social, educational and economic as well. Poverty is accompanied by a number of social factors : low parental educational level, unsanitary housing, family tensions, ignorance of children's needs and of some aspects of the care they require, unsatisfactory mother-child relationship.

Several studies have shown the influence of the environment on the development of malnutrition and on treatment results. It is extremely difficult, however, to separate undernutrition from environment-linked factors, since they are closely intertwined within the social context of actual situations.

There is also evidence that although malnutrition does influence the child's later development, its treatment by nutritional rehabilitation only does not prevent develop-

mental disorders in undernourished children living in an underprivileged milieu. However, individual variations must be taken into account ; some families are more vulnerable to malnutrition and less able to prevent its consequences than others within the same population group. Local customs affecting the child's place in the family and in the community should also be taken into consideration.

According to L. Sinisterra, "the consequences of poverty and malnutrition are frequently clinical, but their causes are not." This lack of equivalence between causes and manifestations is a source of difficulty for health workers, whose specific objectives lead them to limit their action to the growth and physical well-being of undernourished children, in view of their clinical recovery.

In terms of action, the obvious interactions between malnutrition, development and environment demonstrate the need for an overall approach to the problem. A coherent strategy necessarily combines the prevention of dietary deficiencies with the prevention of developmental disorders. This approach is now evident in many nutrition programmes, which recommend psychomotor stimulation of children and family participation in addition to dietary supplementation. Priority must therefore be given to restoring a high-quality mother-child relationship. Mothers gain self-confidence, and take greater interest in their child, when his or her nutritional status improves. It is this process that should be encouraged.

Preventive action focussing on the environment is difficult to implement, since numerous factors are involved. Most exceed the domains of influence and responsibility of health workers. Nonetheless, awareness of children's social and emotional needs may be sharpened at both an individual level and among target groups composed of parents of small children. Education of mothers and their increased consciousness of the development process may considerably reduce the risk of future pathology.

Any intervention programme dealing with diet and the environment must take the local cultural specificity into consideration. The problems of families living in the slums of Cali certainly do not coincide with those of the Katmandu valley.

The country, traditions, the attitudes of caregivers, mothers' reactions to disease and malnutrition, the helpful or harmful aspects of the environment : all are fundamental factors that contribute to an understanding of how children develop harmoniously, and to the choice of appropriate strategies for the prevention of developmental disorders.

APPENDIX 1

GLOSSARY OF THE MAIN PSYCHOMETRIC TESTS

The Bayley infant development scale

A test containing a mental development scale and a motor development scale. These may be administered from birth to age 15 months, and include elements of sensory development, fine and gross motor development and linguistic development.

The Einstein sensori-motor development scale

Measures cognitive functioning, in order to determine the child's level with reference to the stages and substages of development defined by Piaget. This test includes measures of object constancy and spatial relations.

Gesell development schedules

A test covering four spheres : motor characteristics, adaptive behaviour, language behaviour and social behaviour. Includes measurement of equilibrium, locomotion, vigilance, use of hands, vocalizations, play and feeding. Developmental rating scales exist for ages 1 month to six years.

The Griffiths mental development scale

A combination of some elements of the Gesell test and of some new elements. It measures the child's behaviour in the spheres of locomotion, social relations, the links between hearing and speech, sight and use of the hands, the development of achievements. May be used for children from birth to age two years.

The Knox cubes test

This test measures performance without using speech. It evaluates immediate recall by asking the child to reproduce a model shown by the examiner, through a short series of moves of four cubes.

The Peabody "Picture-Vocabulary" test

An intelligence test for 2 to 18 year-olds, using four illustrations, in which the individual must identify the "key word" pronounced by the examiner.

The Stanford-Binet test

A later version of the Binet-Simon IQ test. It contains items for children aged two years to adulthood. The different components of the test are defined for each age, with the corresponding standard deviation.

The Wechsler intelligence scales (WISC)

In addition to the complete measurement of IQ, this test contains specific tests measuring its verbal and performance aspects. The subtests are grouped by subject rather than by age as in the Binet test. This test may be used for children aged five to fifteen.

The Wechsler preschool and primary school scale

Like the WISC, this test contains a complete scale for the measurement of IQ, plus the measurement of verbal and performance aspects, but the items are intermixed so as to increase the small child's interest in the test. It includes ten subtests and is designed for children aged four to six and one half.

APPENDIX 2

FURTHER READING

- d'AGOSTINO M. Early mother-child interaction. In : Children in the Tropics. Paris. International Children's Centre. 1986 ; N 164.

- d'AGOSTINO M., CHAULIAC M., MASSE-RAIMBAULT A.M. Teaching nutrition to young children. In : Children in the Tropics. Paris. International Children's Centre. 1987 ; N 166.

- d'AGOSTINO M., MASSE-RAIMBAULT A.M. Proceed with caution... Children under six. In : Children in the Tropics. Paris. International Children's Centre. 1987 ; N 170/171.

- BARRETT D.E., RADKE-YARROW M., KLEIN R.E. Chronic malnutrition and child behaviour : effects of early caloric supplementation on social and emotional functioning at school age. In :Developmental Psychology. 1982 ; vol. 18 ; N 4 ; pp. 541-556.

- BARRETT D.E., RADKE-YARROW M. Effects of nutritionnal supplementation on children's responses to novel, frustrating and competitive situations. In :The American journal of Clinical Nutrition. July 1985 ; 42 ; pp. 102-120.

- CRAVIOTO J., MILAN R.A. The effect of added systematic stimulation on the mental recovery of severely malnourished infants less than six months old. In : Bulletin of the International Pediatric Association. 1985 ; 6 ; N 1 ; pp. 107-121.

- DOBBING J. Infant nutrition and later achievement. In : Nutrition reviews. January 1984 ; vol. 42 ; N 1.

- DOBBING J. Nutritionnal growth restriction and the nervous system. The molecular basis of neuropathology. Edited by R.H.S. Thompson and A.N. Davidson Edward Arnold. London. 1981.

- DOBBING J. Early nutrition and later achievement. London. Academic Press. 1987.

- DOBBING J., CRAVIOTO J. Nutrition and brain development. In : Annales Nestlé. Vevey, Suisse. 1980 ; N 44 ; 55 p.

- DOBBING J., SANDS J. Vulnerability of developing brain not explained by cell number/cell size hypothesis. In : Early human development. Elsevier/North-Holland Biomedical Press. 1981 ; 5 ; pp. 227-231.

- GALLER J.R., RAMSEY F., SOLIMANO G., LOWELL W.E., MASON E. The influence of early malnutrition on subsequent behavioral development. I : degree of impairment in intellectual performance. In : Journal of the American Academy of child psychiatry. 1983 ; 22 ; pp. 8-15.

● GALLER J R., RAMSEY F., SOLIMANO G., LOWELL W.E. The influence of early malnutrition on subsequent behavioral development. II : classroom behavior. In : Journal of the American Academy of Child Psychiatry. 1983 ; 22 ; pp. 16-22.

● GALLER J.R., RAMSEY F., SOLIMANO G. The influence of early malnutrition on subsequent behavioral development. III : learning disabilities as a sequel to malnutrition. In : Pediatric research. 1984 ; Vol. 18 ; N 4 ; pp. 309-313.

● HURWITZ I. Psychomotric methods. In : Malnutrition and behavior : a critical assessment of key issues (J. Brozek and B. Schürch, eds). Nestle foundation, Lausanne, Suisse. 1984 ; pp. 164-176.

● RANTAKALLIO P., VOU WENDT L., MÄKINEN H. Influence of social background on psychomotor development in the firt years of life and its correlation with later intellectual capacity : a prospective cohort study. In : Early Human Development. Elsevier. 1985 ; 11 ; pp. 141-148.

● WURTMAN Richard J., WURTMAN Judith J. Nutrition and the brain. 2 volumes. Raven Press. 1977.

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